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STRESSES IN CIRCULAR RINGS WITH INTERNAL WATER PRESSURE.

T. H. Hogg, B.A. Sc.

The subject of this paper is the development of the stresses set up in a circular ring under internal water pressure.

The development of the theory is along similar lines to the work of C. W. Filkins and E. J. Fort, who developed the stresses in circular rings due to the weight of the rings themselves, and whose work is published in the "Transactions of the Association of Civil Engineers of Cornell University" for 1896. A reference to similar work is also made in a paper by Mr. Muller in the "Engineering Record" for May 1st, 1909.

The results contained in this paper were arrived at while the writer was working under the direction of Mr. R. D. Johnson of Niagara Falls. It is suggested that Mr. Johnson's article on the Hydrostatic Cord, which appeared in the April 1st, 1910, issue of the Canadian Engineer be read in connection with this paper; as the work contained herein is a development of some of the formulae used by him.

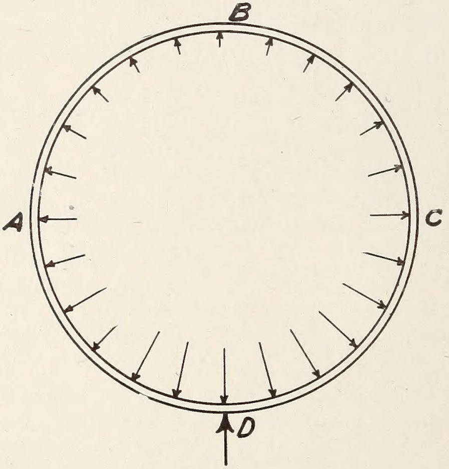
It is usually assumed in figuring the stresses due to internal water pressure in circular rings or pipes, lying on their sides, that it is quite sufficient to take only the tension induced in the shell into account, and that the bending moment may be neglected. This is only true where the pressure head is great compared to the diameter of the pipe. It is easily seen that where this condition does not exist there is a much greater pressure at the bottom of the pipe than at the top, and this may cause relatively great bending moments in the shell.

In the following discussion, the ring is assumed supported on a knife edge, and water pressure is assumed level with the crown of the pipe. The analysis also assumes a thin ring of homogeneous material having a constant modulus of elasticity, and that the changes from a circular form will have little effect upon the dimensions of the ring.

The following nomenclature will be used throughout the discussion:—

H=head of water above top of pipe.

r=radius of circular pipe.
M=bending moment in pipe.
M =bending moment in pipe at top.
M_D=bending moment in pipe at bottom.
M_{max}=bending moment in pipe at maximum point on side.
T=tension in pipe.
T_B=tension in pipe at top.
T_D=tension in pipe at bottom.
ϕ=angle to different points (expressed in radians).
ϕ_{max}=angle to maximum bending moment point on side.
ϕ_u=angle to upper node point (point of no bending moment).
ϕ_l=angle to lower node point (point of no bending moment).
γ=weight of cu. ft. of water.
J=shear at any point.
J_B=shear at top.
J_D=shear at bottom.
$d\delta$=arm of bending moment.



Theoretic Support

FIG 1

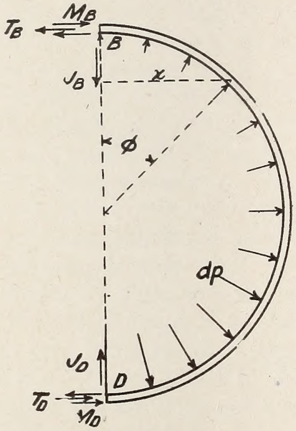


FIG. 2

We will assume that the reader is familiar with the three general formulae for arch-ribs.

$$\int_D^B \frac{Mds}{EI} = \int_D^B d\phi \, ; \int_D^B \frac{Myds}{EI} = \int_D^B dx \, ;$$

$$\int_B^B \frac{Mxds}{EI} = \int_D^B dy \, .$$

The ring is a continuous curved beam to which these equations will apply.

The forces acting upon the pipe may be appreciated by looking at Fig. 1. If we cut the pipe at *B* and *D* and consider the forces acting on the section to the right, we obtain the system of forces shown in Fig. 2.

Taking the centre of moments at the neutral axis at *D* we obtain:

$$M_D = M_B - 2\ T_B\ r + \int_0^\pi (1 - \cos\phi)\ d\,p\ \sin\phi$$

now

$$d\,p = \gamma\ r^2\ (1 - \cos\phi)\ d\,\phi\ ;\ \text{and}\ \sin\phi\ d\,p = \gamma r^2\ (1 - \cos)\ \sin\phi\ d\,\phi$$

Therefore

$$M_D = M_B - 2\ T_B\ r + \int_0^\pi \gamma\ r^3\ (1 - cos\ \phi)\ \sin\phi\ d\,\phi$$

Integrating we obtain:

$$M_D = M_B - 2\ T_B\ r + 2\ \gamma\ r^3$$

Now consider as a free body that portion of pipe shown in Fig. 3.

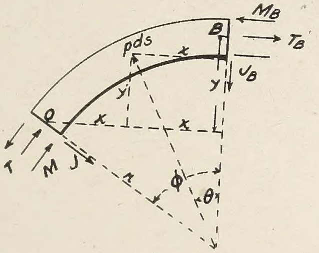


FIG 3

$$E\,I\,\Delta\,y = \int M\,x\,d\,s\ ;\ ds = r\,d\,\phi = r\,d\,\theta$$

$$-M = M_B - T_B\,y + \int_0^B p\ ds\ x$$

$$p\ ds = \gamma\ r^2\ (1 - \cos\ \theta)\ d\,\theta$$

$$x = r\ \sin\ (\phi - \theta)$$

$$y = r\ (1 - \cos\ \phi).$$

Therefore

$$-M = M_B - T_B\,r\,(1 - \cos\phi) + \int_0^\phi \gamma\ r^3\ (1 - \cos\theta)\ \sin\,(\phi - \theta)\ d\,\theta$$

$$= M_B - T_B\,r + T_B\,r\cos\phi + \gamma\ r^3 \int_0^\phi (1 - \cos\theta\ \sin\,(\phi - \theta)\ d\,\theta$$

$$= M_B - T_B\,r + T_B\,r\cos\phi + \gamma\ r^3\ (1 - \cos\phi - \tfrac{1}{2}\,\phi\,\sin\phi)$$

Therefore

$$E\,I\,\Delta\,y = \int M\,x\,d\,s = \int M\,r^2 \sin\phi\,d\,\phi$$

$$= -\int_0^\pi \left[\,(M_B\,r^2 - T_B\,r^3 + \gamma\,r^5)\sin\phi\,d\phi + (T_B\,r^3 - \gamma\,r^5)\sin\phi\right.$$
$$\cos\phi\,d\phi - \tfrac{1}{2}\,\gamma\,r^5\,\phi\,\sin{}^2\phi\,d\,\phi$$

Solving above equation we obtain:

$$E\,I\,\Delta\,y = -\,2\,(M_B\,r^2 - T_B\,r^3 + \gamma\,r^5) + \frac{\gamma\,r^5\,\pi^2}{8}$$

Also $E\ I\Delta\ x = \int_D^B M\ (ds)\ y = O$ since B has not moved horizontally and since its tangent is horizontal.

Now $y = r\ (1 - \cos\ \phi)$; $d\ s = r\ d\ \phi$.

Therefore $E\ I\ \Delta\ x = r\int_0^{\pi r} M\ d\ s - r^2\int_0^{\pi} M\ \cos\ \phi\ d\ \phi$

$$O = r\int_0^{\pi r} M\ d\ s - r^2\int_0^{\pi} M\ \cos\ \phi\ d\ \phi.$$

Substitute value of M found above and solve.

Therefore $-\int_0^\pi M\cos\phi\,d\,\phi = \int_0^\pi [(\,M_B - T_B\,r + \gamma\,r^3)\ \cos\ \phi\,d\,\phi$
$+\ (T_B\,r - \gamma\,r^3)\cos{}^2\phi\ u\phi - \tfrac{1}{2}\,\gamma\,r^3\,\phi\,\sin\phi\,\cos\phi\,d\,\phi]$

Therefore $-\int_0^\pi M\ \cos\ \phi\ d\phi = \dfrac{\pi}{2}\ \left\{T_B\,r - \gamma\,r^3\right\} + \dfrac{\gamma\,r^3\pi}{8}$

$$\text{or} \int_D^B M\,y\,ds = \frac{\pi r^3}{2}\left\{T_B - \frac{3\,\gamma\,r^2}{8}\right\} = O$$

Therefore $T_B = \dfrac{3}{4}\,\gamma\,r^2$

Now $\int_C^B M\,d\,s = O = \int_0^\pi [M_B\,r\,d\,\phi - T_B\,r^2(d\,\phi - \cos\phi$
$d\,\phi) + \gamma\,r^4(d\,\phi - \cos\phi\,d\,\phi - \dfrac{1}{2}\,\phi\sin\phi\,d\,\phi)]$

whence, solving above,

$$M_B = T_B\,r - \frac{1}{2}\,\gamma\,r^3$$

Therefore $M_B = \dfrac{\gamma\,r^3}{4}$

Now $M_D = M_B + 2\,\gamma\,r^3 - 2\,T_B\,r$

$$= \frac{\gamma\,r^3}{4}\,2\,\gamma\,r^3 - \frac{3\,\gamma\,r^3}{2}$$

$$= \frac{3}{4}\,\gamma\,r^3$$

Now $-M = M_B - T_B r + T_B r \cos\phi + \gamma r^3 (1 - \cos\phi - \frac{1}{2}\phi \sin\phi) = \gamma r^3 \left(\frac{1}{2} - \frac{1}{4}\cos\phi - \frac{1}{2}\phi\sin\phi\right)$

which is the general expression for the bending moment.

To find the shortening of the vertical diameter substitute the values of M_B and T_B in the equation.

$$E I \Delta y = -2 (M_B r^2 - T_B r^3 + \gamma r^5) + \frac{\gamma r^5 \pi^2}{8}$$

We obtain: $E I \Delta y = -\gamma r^5 + \frac{\gamma r^3 \pi^2}{8}$

$$\Delta y = \frac{\gamma r^5}{E I}\left(\frac{\pi^2}{8} - 1\right) = + .2337 \frac{\gamma r^5}{E I}$$

To find the lengthening of horizonthal diameter

$$E I \Delta x = \int^B M (ds) y$$

Therefore

$$-E I \Delta x = \int_0^{\frac{\pi}{2}} [(M_B - T_B r + \gamma r^3) r^2 (1 - \cos\phi) d\phi$$

$$+ (T_B r - \gamma r^3) r^2 (\cos\phi - \cos^2\phi) d\phi - \frac{1}{2}\gamma r^5 (1 - \cos\phi) \phi \sin\phi \, d\phi$$

Solving $-E I \Delta x = \frac{\gamma r^5}{4}(1.5\pi - 5)$

$$= -.0719 \gamma r^5$$

Therefore $\Delta x = .0719 \frac{\gamma r^5}{E I}$

The whole change in horizontal diameter

$= 2 \Delta x = .1438 \frac{\gamma r^5}{E I}$

In order to find the value of ϕ where the moment is a maximum, place $\frac{d M}{d \phi} = O$

Therefore $T_B r d \cos\phi - \gamma r^3 d \cos\phi - \frac{1}{2}\gamma r^3 d\phi \sin\phi = O$

Differentiating and simplifying we obtain:

$$\phi \cot\phi = -\frac{1}{2}$$

$$-2\phi = \tan\phi$$

By trial we find $\phi = 105^\circ - 13' - 45''.4$; also $\phi = O$.

Now, when $\phi = O$ the maximum moment $M_B = \frac{\gamma r^3}{4}$

When $\phi = 105^\circ - 13' - 45''.4$ substitute in exrpession for moment

$$-M = M_B - T\ r + T_B\, r \cos\phi + \gamma r^3 \left(1 - \cos\phi - \frac{1}{2}\phi\sin\phi\right)$$

and we obtain $M = -.3203\,\gamma r^3$

Assembling and comparing the values of the moments found we see that $M_B = +\frac{\gamma r^3}{4}$; $M_D = +\frac{3\gamma r^3}{4}$

and $M_{\text{Max}} = -.3203\,\gamma r^3$

Therefore, we see that the moment of the stress couple changes sign (i.e., passes through zero) between M_B and M_{Max} and between M_{Max} and M_D

Place M in general equation equal to zero and solve for ϕ

$$\gamma r^3 \left(\frac{1}{2} - \frac{1}{4}\cos\phi - \frac{1}{2}\phi\sin\phi\right) = M = O$$

Therefore, $\phi\sin\phi + \frac{1}{2}\cos\phi = 1$

or $\phi = 50^\circ - 36' - 45''$,
also $\phi = 146^\circ - 19' - 25''$.

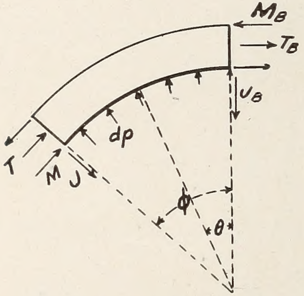


FIG. 4

Now, considering Fig. 4, we see that value of

$$d\,p = \gamma r^2 (1 - \cos\theta)\, d\,\theta.$$

Therefore the sum of the vertical components of all the $d\,p$'s between

$$O \text{ and } \phi = \int_0^\phi d\,p\cos\theta = \int_0^\phi \gamma r^2 (1 \cos\theta)\cos\theta\, d\,\theta$$

$$= \gamma r^2 \left(\sin\phi - \frac{1}{2}\phi - \frac{1}{4}\sin 2\phi\right)$$

And the sum of the horizontol components of all the $d\,p$'s between O and ϕ

$$= \int_0^\phi dp \sin\theta = \int_0^\phi \gamma r^2 (1 - \cos\theta) \sin\theta \, d\theta$$

$$= - \gamma r^2 \left(\cos\theta \, \phi - 1 + \frac{\sin^2\phi}{2}\right)$$

In Fig. 4 place vertical components of the acting forces equal to zero.

Therefore,

$$J \cos\phi + T \sin\phi = \gamma r^2 (\sin\phi - \frac{1}{2} \phi - \frac{1}{2} \sin\phi \cos\phi)$$

Placing horizontal components equal to zero,

$$J \sin\phi - T \cos\phi = \frac{3}{4} \gamma r^2 - \gamma r^2 \cos\phi + \gamma r^2 - \frac{1}{2} \gamma r^2 \sin^2\phi$$

solving these equations for T and J we obtain:

$$T = \gamma r^2 (1 - \frac{1}{2} \phi \sin\phi - \phi - \frac{1}{4} \cos\phi)$$

$$J = \gamma r^2 (\frac{1}{2} \phi \cos\phi + \frac{1}{4} \sin\phi)$$

The above discussion has assumed that the pipe is just filled with water to the top. We can easily see that the bending moments are not affected by the water pressure after the top is passed. In other words, the bending moments induced in the shell are caused by the difference in pressure between the top and any other point chosen; and this difference remains constant for any head above the top. The tension in the shell, however, varies directly with the head and is equal to $H \gamma r$, where H is the head on the top of the pipe.

This amount must be added to the above obtained value of the tension to obtain the general expression.

Collecting the formulae we have

$$M = \gamma r^2 (\frac{1}{2} - \frac{1}{4} \cos\phi \; \frac{1}{2} \phi \sin\phi)$$

$$T = H \gamma r + \gamma r^2 (1 - \frac{1}{4} \cos\phi - \frac{1}{2} \phi \sin\phi)$$

$$J = \gamma r^2 (\frac{1}{2} \phi \cos\phi + \frac{1}{4} \sin\phi)$$

$$M_B = \frac{1}{4} \gamma r^3$$

$$M_D = \frac{3}{4} \gamma r^3$$

$$M_{Max} = - .3203 \gamma r^3$$

$$T_B = H \gamma r + \frac{3}{4} \gamma r^2$$

$$T_D = H \gamma r + \frac{5}{4} \gamma r^2$$

$$\phi_{\text{Max}} = 105^\circ - 13' - 45''.4$$

$$\phi_u = 50^\circ - 36' - 45''$$

$$\phi_L = 146^\circ - 19' - 25''$$

$$\Delta x = .0719 \frac{\gamma r^5}{E I}$$

$$\Delta y = .2337 \frac{\gamma r^5}{E I}$$

In order to show the results clearly let us plot a bending moment diagram. We can always express the bending moment in terms of the tension multiplied by the arm of the moment. Therefore, if we divide the bending moment at any point by the tension at the same point, we obtain the arm of the bending moment at that point.

Let $d\rho = \frac{M}{T}$ = arm of bending moment.

$$= \frac{\gamma r^3 \left(\frac{1}{2} - \frac{1}{4} \cos\phi \frac{1}{2} \phi \sin\phi\right)}{\gamma r \left\{ H + r \left(1 - \frac{1}{4} \cos\phi - \frac{1}{2} \phi \sin\phi\right)\right\}}$$

$$= \frac{r\left(\frac{1}{2} + k\right)}{\frac{H + r}{r} + k} \quad \text{where } k = -\frac{1}{4} \cos\phi - \frac{1}{2} \phi \sin\phi$$

Plotting the values of $d\,\delta$ radially, for different values of ϕ we can represent the bending moment as shown in Fig. 5. This curve is the equilibrium polygon for the assumed conditions.

The above formulae taken together with the formulae for the weight of the shell itself, a reference to which was made at the beginning of this paper, are extremely useful; in fact, absolutely necessary to the correct design of concrete pressure pipes of large diameter.

On account of the node points (points of zero bending moment) and points of maximum bending moment occurring at the same points, both for the weight of the water itself and the weight of the shell, and because the bending moments due to both causes are exactly proportional at all points on the circumference it follows that they may be readily combined. With the above formulae, therefore, and those for the weight of the shell the design of pressure pipes of large diameter becomes a comparatively simple matter.

The above method of analysis, based on the general formulae for continuous arch girders, may also be used to determine the stresses induced in the shell for different loads applied on the top and sides, such as back-fill, etc.

The writer is sorry that lack of time prevents him from entering more fully into the methods of combining the several

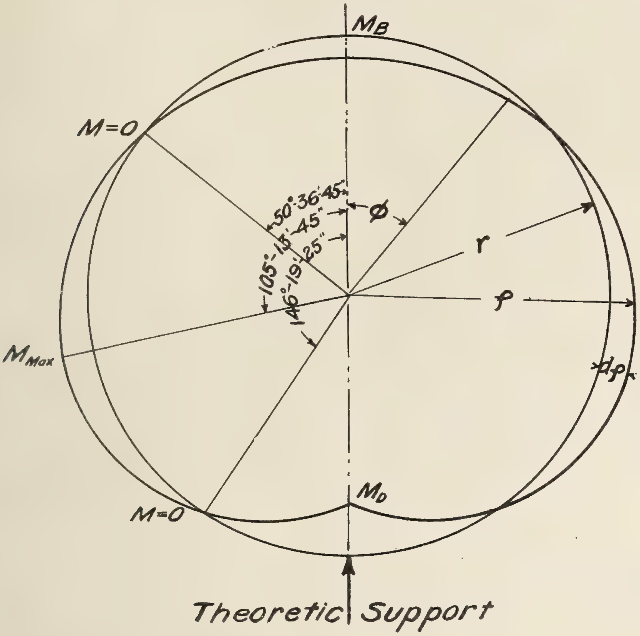


FIG 5

stresses due to weight of shell, weight of water, water pressure, back-fill and top loads, as many interesting problems arise in the application to an actual design.

RADIO-TELEGRAPHY.

L. T. RUTLEDGE, B.A.Sc.

All signalling at a distance necessitates the use of three distinct parts: the device which produces the signal, that which carries it, and that which receives it. These three essentials we may call the sender or transmitter, the line and the receiver. Now, in the case of wireless telegraphy, something in space is the medium of propagation, and it is the object of the writer to discuss the conditions which make it possible for telegrahpic messages to be sent from one continent to the other with seemingly nothing passing from one to the other.

The first point in this connection is to get a clear idea of the fields that are set up in space by electric currents and charges. It is well known that a current, even in a straight conductor, sets up an invisible magnetic field in the space surrounding it. In this case the field consists of magnetic lines that surround the conductor. Now let us briefly consider the state of the space that lies between any surface that is charged with a positive charge and the neighboring surface that is charged negatively. The dielectric, whether air or glass, between the two surfaces that are charged, is in a state of electric strain, there being electric lines of force through it from positive to negative, and these constitute an electric field.

Now consider a circuit in which there is an oscillating current. Fig. 1 represents a simple condenser made of two flat metal plates, with a layer of air between them. They are joined by a simple circuit made of bent brass rods, ending in polished balls with a spark gap between them, so as to be able to start oscillations by connecting to a suitable source, such as an induction coil. Just before a spark passes, one of the metal plates is highly positive and the other highly negative, and then there will be an electric field across the air space between them. When the spark occurs, the positive charge rushes round the circuit into the plate that was negative and then surges back again with incredible rapidity, oscillating along the conducting circuit. Each such rush constitutes a current, and as the successive rushes are in opposite directions, the conducting rods become the seat of an alternating current of high frequency. Therefore in the space surrounding the bent rods there will be set up an alternating magnetic field. The magnetic field surrounding the wire will be strongest when the rushing current is strongest, and this occurs precisely at the moment when the condenser has been emptied and before it is charged up again by the continuance of the rush. But the electric field, which will also be alternating, and which lies in the crevice between the plates, will be strongest when the rush either way is finished, and the charge in the condenser is at its height. So we here see that the

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* **Read before Electrical Club, University of Toronto, Nov. 1910.**

magnetic and electric fields occur at different places and have their maxima at different times. It has been experimentally proved that under such conditions no electric waves can be emitted; it here being taken for granted that electric oscillations occurring under the proper conditions give rise to what are known as "electric waves," a phenomenon which many years ago has been well studied and described by many eminent scientists.

Let the condenser of Fig. 1 be opened up into the form shown in Fig. 2, with the two metal plates, .WW., extended

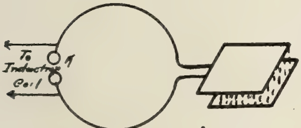

Fig. 1

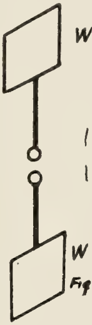

Fig 2

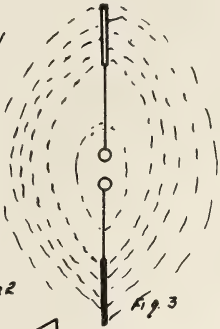

Fig. 3

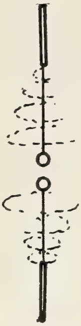

Fig 4

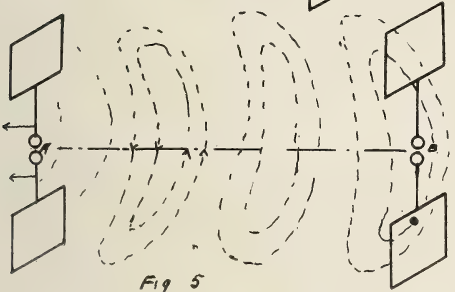

Fig 5

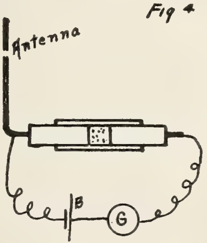

Fig 6

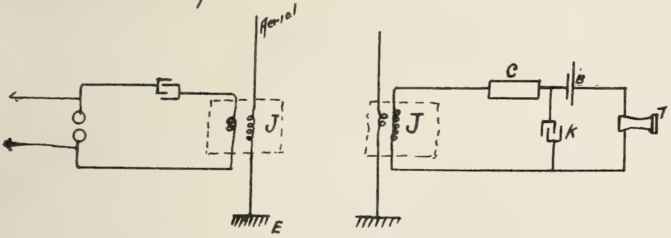

Fig. 7

out like wings, and conductor with spark gap, A, in the middle made straight. As before, air is the dielectric. When they are charged, there will be an electric field from one to the other as in Fig. 3. If a current were rushing up and down from one to the other, there would be a magnetic field, as shown in Fig. 4. Now, when a spark is made to pass, setting up a series of oscillations, the electric field between the wings will extend, as the dotted lines show, right across the space where the magnetic field will occur during the rushes of the current up and down the rod. The electric field will not have died away before the magnetic field has begun to grow, so that both kinds of fields can be present in the same space at the same time, and while the electric lines will be mainly parallel to the conductor the magnetic lines will be transverse whirls around it. For the production of electric waves it is necessary that there should be both an electric field and a magnetic field at the same point of space and at the same time. This simple apparatus is capable, then, of throwing off into the space surrounding it an electric wave at each oscillation. Such waves do not return back into the system, but go travelling off into space with the speed of light, following one another as in Fig. 5. The more the metal plates present of free surface, the more freely do they radiate off electric waves. If they consist of flat metal the electric waves radiate off more freely from the flat faces than from their ends or edges. If set vertical they radiate out mainly in front and behind, but they may be set horizontally at the ends of the system. The late Professor Hertz devised this simple apparatus in 1887 for the manufacture of electric waves. It is known as a Hertz Oscillator.

Now, to detect these waves, Hertz placed in another part of the room an exactly similar apparatus with two plates and a minute spark gap, as shown on the right of Fig. 5. The spark gap B was not more than 1-1000 inch, otherwise the induced electromotive force was not able to make the spark jump across the air space. Hertz, on placing an oscillator and a detector like these, a few feet apart in a room, found that a spark occurred at B every time a spark occurred at A. This induced emf. was seen to be due to waves emitted from the oscillator and caught by the detector. Hertz was also able to show that these electric waves could be reflected from a large sheet of metal or collected by a parabolic mirror or refracted through a prism of pitch; in fact, they behaved like waves of light, only they were quite invisible.

These results obtained by Hertz led other men to experiment. Branly discovered that a heap of metal filings possesses the very curious property that although they are usually a very bad conductor because of the innumerable imperfect contacts among the particles, they yet become a much better conductor when an electric spark is made anywhere near them. Lodge found that the imperfect contact made a pointed wire resting against a metal plate to be sensitive to the action of an electric wave. Such imperfect conductors are called coherers. Taking advantage of Branly's observations, Lodge constructed a coherer of metal filings enclosed in a small glass tube between metal rods inserted at the ends, and this proved very sensitive, but he found that it required to be tapped after each operation to cause the filings to decohere, and proposed methods of automatic tapping which will be touched on later.

The method in which the coherer was used to detect the electric signals is as follows: The coherer was connected to a voltaic cell and a galvanometer in series. The coherer has so poor a conductivity that practically no current flows. Directly an electric wave falls upon the coherer or upon the wires attached to it, it sets up oscillations, and probably also sets up minute sparks in the air gaps between the filings. Whether this is so or not, it increases the conductivity of the filings so that the cell is able to send enough current through the circuit as is detected by the galvanometer (see Fig 6.) Lodge found considerable advantage in fastening to the coherer an extended wire as an antenna to receive the wave. In his early experiments he put the whole apparatus in a tight metal box to exclude the effects of any stray waves, the only thing projecting out of the box being the receiving antenna. With such a coherer he was able to extend the distance between transmitter and receiver to two miles.

He also extended the distance by using at the spark gap a single polished ball between two smaller ones.

In the Hertz upright oscillator, as in Fig. 5, the capacity plates at the top and bottom ends of the oscillator are the places which become most highly charged, the middle part of the connecting system being as it were a node in the waves. The same would be true of the same apparatus if used as a detector. The ends are the places which receive the maximum charges of potential. The middle part is the seat of the strongest currents, and whole loops of waves are sent out. But this is no longer the case if the oscillator or receiver is earthed, as to the lower half, and the node in the electric wave occurs just above the earth and waves of which half are in the air are sent out.

This idea of having half the wave travelling in air and the other half in the ocean or earth is of great advantage. The waves maintain continuous contact with earth, are not sent through space, but undulate along the surface, and cannot be reflected by earth into space as they would be if the waves were closed upon themselves; so this prevents the dispersion of energy in any disadvantageous direction, and at the same time facilitates its transmission in the useful direction, that is to say, in the horizontal, and in practice it is found that the intensity of the wave does not diminish more rapidly than the simple inverse of the distance from the centre of emission.

Since the earth takes an essential part in the transmission of waves it must be of good conductivity; wet soil or sea. Earthed apparatus does not work over a dry desert. The movement of the half loops of electric waves outward from an earthed oscillator as distinguished from the non-earthed oscillator used by Hertz and Lodge, is hindered by a bad conductivity on the earth's surface, but is helped by the fairly good conductivity of the sea. On the other hand, for non-earthed oscillators emitting whole loops of waves, the conducting power of the earth is no help.

The first wireless telegraphing was done by Sir Oliver Lodge, who, in 1894, sent wireless signals through stone walls and from one building to another, using as a detector a filings coherer as described, the system being untuned. Signor Marconi at first made his experiments with a coherer put to earth in circuit with a single cell and a sensitive telegraphic relay, which in turn actuated an ordinary Morse instrument, printing dots and dashes. In 1898 Marconi adopted the plan now claimed essential to his system of using a tall mast like a lightning conductor, the lower side of the spark gap being connected to earth and called "the aerial wire," or "antenna," or "earthed vertical oscillator."

The frequency of the oscillations is determined by the capacity and self-induction of the apparatus and also by the length from the node to the ends and the surface presented. Also any evils introduced into it will increase its self-induction and lengthen the waves. An oscillator like Lodge's or Hertz's has relatively large surface and small self-induction and will radiate so freely that the wave train will die out after very few oscillations. Owing to the fact that the Marconi aerial resembles the Hertz oscillator in possessing a large radiation surface, it cannot send out such trains of waves as would be required for syntonic working, or in other words, it is necessary to tune the instruments and the aerial. In none of the early operations could tuning be secured, and they were liable to interference from stray disturbances in the atmosphere.

With regard to tuning we must observe that the receiving apparatus is a vibrator similar to the sender, and therefore on the first arrival of an electric impulse electrical vibrations will be produced in it, having periods similar to that of the receiving apparatus. The same effect will be produced with the arrival of each wave, and since the effects are additive, it is necessary that the arriving waves should have the same rhythm or period as those which are set up in the sky rods, otherwise the vibrations set up by the successive impulses will overlap each other, irregularly weakening each other, and producing what is called interference of waves. Therefore when waves are striking the rceiving apparatus it is the duty of the operator to vary the capacity and inductance of his apparatus so that his apparatus will vibrate with the same rhythm as the distant transmitting apparatus, and in practice the high clear note is found to be the one desired, that is, if a telephone were connected in the coherer circuit one should hear clear high notes for best working. When the receiving apparatus is so set as to receive messages it will generally be found that a hum can be heard in the telephone. Stray disturbances in the atmosphere, perhaps static disturbances, or stray waves emitted from some place or other cause this, and therefore if station A wishes to converse with station B the apparatus of the receiving station must be tuned such that the required message is heard above these other minor ones. As stated before, the high note is required for good working, and the higher the note the easier it is for the operator to distinguish it. Also in this connection it might be well to note that waves should not be damped. Damped waves diminish and die away after a few vibrations. Damping may be caused by too high resistance in conductors, spark gaps, etc. A high sky rod reduces damping and so does putting part of oscillator to earth. If a source of persistent oscillations could be applied, the receiving apparatus could be tuned to the sending apparatus, and thus the whole system be rendered far more sensitive for long-distance work. To do this the sending apparatus must in some way be linked up with an oscillation circuit, and the distant receiving apparatus should similarly be supplied with an oscillation circuit; then the two can be tuned to the same frequency of oscillation. There are more ways than one of associating the wave apparatus with an oscillation circuit. The most usual one is by means of an oscillation transformer, called in telegraphic language a "jigger," and is due to Sir Oliver Lodge. This induction transformer is a simple arrangement for a primary coil of one or two turns surrounding or surrounded by a secondary coil of a larger number of turns. A simple form of jigger is shown in Fig. 7; J is the jigger, represented by two separate spirals, K the condenser, C the coherer. When the primary coil is traversed by oscillations they induce other oscillations in the secondary circuit, but these last are feeble unless a condenser is put across the secondary terminals and the two circuits brought into resonance.

Besides the advantage gained by tuning, there is another advantage of putting the oscillation transformer into the receiving circuit. For at the node of the receiving aerial the potential is a minimum, and the current a maximum. Therefore as the coherer depends on the potential and not on the current, the node is a bad place to insert the coherer, as was done at first. By placing in the node the primary of the transformer and inserting the coherer in the secondary, the increased voltage so applied to the coherer was found to increase its sensitiveness considerably, and therefore greatly extended the range of working. Marconi being desirous of working over still greater distance, adopted (in 1899) the jigger into his arrangements, and was able to signal eighty-five miles. For transmitting oscillations the transformer was generally constructed as follows: It consisted of a square wooden frame wound over with a number of lengths of highly insulated, stranded copper cable, joined in parallel, so as to make a primary of one turn. Over this is wound a secondary of from five to ten turns. The oscillation transformer is usually immersed in oil.

Having obtained the syntonisation of the stations in such a manner that the receiving station will only answer to the wave emitted by a station tuned to its period, it will be easily understood that if there be several receiving stations, each one tuned to a different period of electrical oscillations, and whose corresponding length of wave is known at the sending station, this latter can tune its own apparatus in such a manner that the despatch shall be received by one determined station among these, and then modify the tuning in order to communicate with another, the message with the first having ceased, and so on.

The problem of multiple communication, that is to say, the communication simultaneously to several stations in any direction and in a similar radius of action, is therefore intimately associated with that of syntonisation. It will be easily understood that a given station will have greater importance even from the business point of view in proportion as the number of special stations with which it can communicate, be greater.

Marconi has contrived a way by which he can at one and the same time transmit from a single station several messages. In 1903, in Italy, he sent five messages at once from a single sky rod. As spoken of before, tuning can be accomplished by changing capacity, inductivity or both. Signor Marconi, for greater facility and certainty of action, causes conductors of different capacity and inductance to be thrown into contact with the aerial and having it arranged so that this can be done for each transmitting apparatus, then no two will have the same wave form and thus two or more signals can be leaving the aerial at the same time. The receivers can be similarly fixed so that each will take care of its own messages.

In passing from the theoretical discussion to a discussion of practical apparatus as is used by wireless companies, it might be stated that to fully discuss the theory of radio-telegraphy, higher mathematics should be made use of, as, for instance, to show relations existing between wave length and capacity. Also the formulae for induction frequency, wave length and capacity could be derived, but space is too limited for that phase of the subject.

An ordinary wireless station contains at least one transmitting set and one receiving set. If it is a station that is supposed to work within a radius of five hundred miles, the transmitting set will likely consist of a motor generator set, an oscillation transformer, a variable inductance and capacity in the form of coils and condensers, a spark, gap, a key, and an aerial. The receiving apparatus has the same aerial as part of it, a detector of some kind, as, for example, the coherer, a tuning device consisting of inductance coils and condensers, a telephone or some recording telegraphic device or sounder, including the necessary wiring and switches. A large transmitting station, such as a trans-Atlantic one, needs more apparatus than a simple motor generator set for generation of power. In such a station we find the accumulator house, the condenser house, a boiler room, engine room, an operating room and a high tension room and an arial covering several acres, all of which will be discussed in detail.

Transmitting Apparatus.

For short-distance spark telegraphy the necessary high potential is always obtained by the use of an induction coil or transformer; either a single instrument or a number of induction coils or transformers may be employed, having their secondary circuits joined in series and their primary in parallel.

The most usual appliance is an induction coil of the ordinary type, having a spark length of ten inches and taking current from storage batteries or from a small single phase alternator. The induction coil is placed on the table in the transmitting station, or it may be fastened to the wall. It may be operated either by alternating current or an interrupted continuous current.

The next element in the transmitting apparatus is the signalling key for interrupting the primary circuit in accordance with the signals of the Morse alphabet or Continental code. This must be a quick break key with a long ebonite handle easily operated, and has generally a magnetic blow-out in connection with the platinum terminals between which the interruption takes place. Marconi has tried several kinds of keys. Some have the points touch in air, some in a recipient filled with paraffin. He uses in his key circuit a condenser in shunt so as to do away with self-induction sparks on opening or closing the circuit. Also if an alternator is used a provision is made to save it, since it is running all the time. Marconi puts in parallel with the key a reaction coil whose reactance when its core is completely immersed is such as to damp entirely the exciting current. Every time the key is closed the current excites the primary of the transformer and discharges are produced and on the other hand when the key is raised, the exciting current is annulled by the reactance and the discharges cease without any necessity of altering the working of the alternator.

Reference has previously been made to the oscillating transformer or jigger. Marconi prefers to connect the aerial inductively with the energy-storing circuit by the oscillation transformer. It consists of a few turns of primary winding wound on a wooden frame and more turns of a secondary connected in series with the aerial that has a variable inductance between this secondary winding and the earth connection. This last mentioned inductance is really a turning coil. A condenser is put in series with the line leading to one end of the primary of the jigger and the spark gap is connected in parallel with the primary coil having this condenser in a line between the spark gap and primary winding.

Reference might here be made to what happens when two oscillation circuits are connected together inductively and in tune with one another: oscillations set up in one circuit results in the production of oscillations in both circuits, having two frequencies, one greater and the other less than the natural frequency of each circuit when separate. Hence when employing an induction coupled antenna which has been syntonised with the condenser circuit, it is necessary to bear in mind that oscillations of two frequencies are set up in the antenna and waves of two wave lengths radiated from it, one greater and the other less than the wave length corresponding to the natural frequency of the antenna taken alone. One of these waves has greater amplitude than the other, the longest wave length being the least damped and therefore having the greatest integral value. The wave lengths approximate to one another in proportion as the coupling is made weaker but then they also diminish in amplitude so that by the employment of a weak coupling, which can be done by separating the primary and secondary of this transmitting jigger, we get a radiation which is a little feebler but of a single wave length, whereas by close coupling we get more powerful waves but waves of two wave lengths radiated, and the receiving antenna must accordingly be syntonised to one or other of these wave lengths.

As regards condensers for the oscillation circuit, although a Leyden jar is a bulky form of condenser in comparison with its energy storing power, nevertheless its simplicity still recommends it. The main condenser consists of a battery of them joined partly in parallel and partly in series. It is very important that the capacity of the condenser is exactly known and the jars selected so as to be exactly equal to eliminate as far as possible electric brush discharges. The condenser can be constructed of plates immersed in oil. Brush discharges are thereby prevented and accuracy of tuning is secured by preserving a constant known capacity in the condenser circuit. Exact syntonisation between condenser circuit and aerial circuit is absolutely necessary. Other things being equal the radiation will be in proportion to the mean square value of the current flowing into the base of the antenna. The current may be measured by inserting in that point a hot wire ammeter.

Another important element in the transmitting arrangement is the spark discharge. When large capacities are being employed the noise of this spark is distressing and any one who understands the code can read the messages at a great distance. The spark balls should be enclosed and have alkaline material close by for absorbing acid vapors or gases. It is of great advantage to blow a jet of air upon the spark gap to quench the arc. A spark gap can be done away with and a Poulsen arc substituted in its place. This is a device invented (in 1903) by Poulsen of Copenhagen. He produced an electric arc between a carbon rod as a negative and a copper rod as a positive terminal, the latter being kept cool by water circulation. This apparatus gives very powerful undamped oscillations, the frequency of which by a proper selection of capacity and inductance, can be made to be as high as a million or more, and quite within the range of those required for radio-telegraphic work.

Marconi in his large stations has made use of a new device for discharging, known as the High Speed Discharger. In one form of it, there are caused to rotate rapidly by electric motors or other means two discs with perforations. Between these, and insulated from them, another disc (with its plane at right angles to the other two) rotates at a high speed. This plane and the two discs are connected in the circuit with inductances and condensers. At a certain potential, the condensers discharge with oscillations across one or other of the air gaps between the rapidly revolving disc. The arc discharge which attempts to follow in the track of the oscillation is however prevented by the rotation of the discs from taking place. A very high piercing note is produced by this sparking apparatus.

The length of antenna varies with the size of the station. A small five kilowatt station for operating up to 500 miles would have a tower about 150 feet high, situated on some high point, and having bare wires leading in a downward direction. Another scheme is to use two towers joined by bare wires and a tie-arrangement leading to receiver. In the very large stations as for example the Glace Bay Station, the Clifden Station on the coast of Ireland, or the Poldu station of Cornwall, more extensive aerial is required. At the Glace Bay Station at Cape Breton Marconi has four towers built with a cone shaped envelope of wires suspended from the top of the towers, thus making it possible to have a large radiation surface. The aerial apparatus at the German station of Nauen near Berlin is pretty extensive. That company uses there a steel tower 328 feet high built so as not to vibrate, the tower being triangular and thirteen feet to a side. The tower is insulated from the earth as well as the guy cables. The antenna is sloped like an umbrella, the tower representing the rod. The aerial is divided into six sections, the upper part consisting of six sections of 54 wire cables, nine in each of the six sections. At a point 82 feet from the top of the tower each cable divides into three so that there are 162 cables altogether. The aggregate surface enclosed is fifteen acres. The cables are insulated from the ground and led in parallel to the station. The ground contact is made through a system of 108 wires buried in low wet ground. These wires divide as they diverge, and the area enveloped is thirty-one acres. There are altogether 324 wires in the ground. Most of Marconi trans-Atlantic stations are situated near the coast in the very wettest piece of ground he can find in the region. The station at Glace Bay is in a very desolate, lonely swampy place.

Just here it might be well to speak of the transmitting apparatus of the Nauen station. The operating rooms occupy a brick building, the ground floor of which contains the dynamo, the transmitting office and the work ship. All the high tension apparatus is placed in the second storey where it is free from dampness and hence more perfectly insulated. The power is furnished by a 35 H.P. engine which drives a single phase alternator coupled to an exciter on the same shaft. This generator at a speed of 750 R.P.M., furnishes 25 kilowatts of electrical power in the form of a single phase current of 50 cycles per second. In the circuit are fusible plugs, voltmeter, ammeter, frequency indicator, a transmitting and cut out relay. Four large inductance coils are in the dynamo circuit, in addition to the four transformers which produce the high tension transmitting current. The transmitting circuit also includes a battery of 360 Leyden jars arranged three in series by 120 abreast and having an aggregate capacity of 400,000 coulombs.

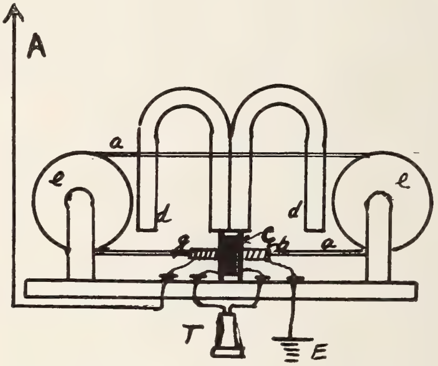

Fig 8.
MAGNETIC DETECTOR

This station just described has sent messages 1500 miles over water and received telephonic messages from St. Petersburg a distance of 840 miles.

Marconi, to transmit messages across the Atlantic, uses an installation of 75 kilowatt capacity, the voltage being transformed up to about a quarter to half a million volts.

Receiving Apparatus.

The discussion of receiving apparatus centres around that of a special part of it known as the detector. There are indeed many forms of detector of electro-magnet waves from the old filings coherer to the latest inventions of magnetic and electrolytic detector and lastly the famous Fleming Valve Receiver.

Marconi first used a coherer as a detector. It had nickel filings with four per cent. silver in it. The dimensions of such a coherer are 1½ inch long, 1-10 inch internal bore with silver stoppers 1-5 inch long and the space between for filings being 1-50 inch. With this delicate apparatus 1.5 volts was the maximum voltage he used and one milli ampere was the maximum current sent through by a single cell. He used a decoherer in the form of a hammer actuated by an electromagnet which just struck a rubber pad on the coherer tube.

The second type of coherer used was a magnetic one. It was discovered that electric waves can exercise a demagnetizing influence upon a highly magnetized small steel needle and a magnetic detector of waves on this principle was made. Marconi for telegraphic work invented an improved form of detector a diagram of which is given in *fig.* 8, made as follows: Two wooden discs e,e, grooved on the edges are driven mechanically by clock work. An endless band a,r, made of a bundle of fine silk-covered iron wires, is arranged like a belt over these pulleys and moves forward at the rate of about three inches per second. At one place the iron band passes through a glass tube, g.b., on which is wound a coil of insulated wire through which oscillations can be passed and this coil is embraced in the centre of another coil, c., connected with the telephone T. A. pair of horse-shoe magnets are placed with their similar poles together opposite to the last mentioned coil as shown in the diagram. If electric oscillations pass through the coil wound round the band they change the magnetic state of the iron and generate an induced in the secondary coil and hence a current and sound in the telephone. The operation of this instrument was considered by Marconi to be due to the power of electric oscillations passing through the coil surrounding magnetized iron to annul the hysteresis of the iron. A magnetic detector like this is found to work, when there are static disturbances a little better than some other detectors.

The third and present detector used by Marconi is known as the Fleming Valve Receiver, invented by J. A. Fleming, M.A., D.Sc., Pender Professor of Electrical Engineering in the University of London. He first used an ordinary incandescent lamp with carbon filament and having a metal plate included in the glass bulb or a metal cylinder placed around the filament, the said plate or cylinder being attached to an independent insulated platinum wire T, sealed through the glass. When the carbon is rendered incandescent by electric current, the space between the filament and th plate, occupied by highly rarefied gas possesses a unilateral conductivity and negative electricity will pass from the filament to the plate but not in the opposite direction. This depends upon the well-known fact that carbon in a state of high incandescence liberates negative ions. A practical lamp has been made—a small incandescent lamp with a rather thick filament taking about 2 amperes at a terminal voltage of 12 volts. *Fig.* 9 shows how this detector is used in radio-telegraphy work. The antenna A, is coupled through an oscillation transformer with a circuit which includes the valve, O, and the fine wire coil of an ordinary 10-inch spark induction coil, I, the low resistance coil of which is in circuit with the telephone T. Condensers are placed across the secondary circuit of the oscillation transformer and also in series with the fine wire coil of the large induction coil. By suitable adjustments of the capacity of this condenser the circuits are brought into resonance. Oscillations taking place in the antenna, due to the impact of electric waves upon them are then transformed by the jigger, rectified by the oscillation valve and sent through the fine wire coil of the large induction coil in the form of a unidirectional but intermittent current and these oscillations are again transformed up in current value by the large induction coil. In this way a sound is created in the telephone. So used, the oscillation valve becomes one of the best long distance receivers for electric waves yet devised .

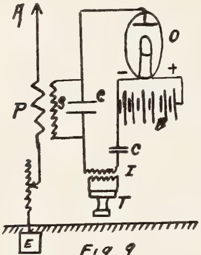

Fig 9
CONNECTION FOR
FLEMING VALVE

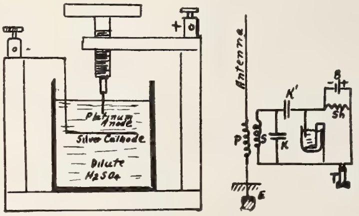

Fig. 10
ELECTROLYTIC DETECTOR

At the top of the departmental store of John Eaton, Esq., Toronto, is a wireless station which has all three of the Marconi type of detector installed and in first class condition, the station being of two kilowatt capacity. Power is furnished by a motor-generator set at 500 volts and the voltage is transformed to 12000 by the oscillation transformer. The spark used is five-eights inch long, being two gaps in series. The operator can intercept messages sent out from the Atlantic stations near New York and is in daily communication with the Clarke Great Lake stations. The high efficiency of this station is due to the excellent tuning apparatus a wiring diagram of which is shown in *Fig.* 11. The Fleming valve is the detector shown. Two valves are installed, only one being in use at a time. Neverthless they find the magnetic detector the better during static disturbances in the atmosphere. A fine adjustment for tuning is to be had in the billi-condenser. When the operator is just listening the switch is on the stand-by side but when communication is opened up with any one particular place it is thrown over to the tuning side and the receiving apparatus is tuned to read the required message, the tuning cutting out all stray disturbances and messages of other stations. The wave length for this outfit is about 300 metres. It possesses an advantage over the Clarke system in the operator being able to receive and transmit at practically the same instant: all that is necessary to receive is to stop working the key whereas in the Clarke Lake stations a lever has to be moved which (to accomplish) takes a little time.

Besides the form of detector used by Marconi an American company headed by Fessenden uses an electrolytic detector. It is shown in *Fig.* 10. It consists essentially of a vessel having as one electrode a very fine short wire of platinum offering therefore an extremely small surface. This electrode is generally made the anode. The other electrode is a silver plate. The electrolyte is sulphuric acid. The cell becomes polarized but electric oscillations depolarize it, thus allowing a current to circulate and giving rise to a sound in the telephone. When the wave ceases it is again polarized. It is quite automatic in action and very efficient.

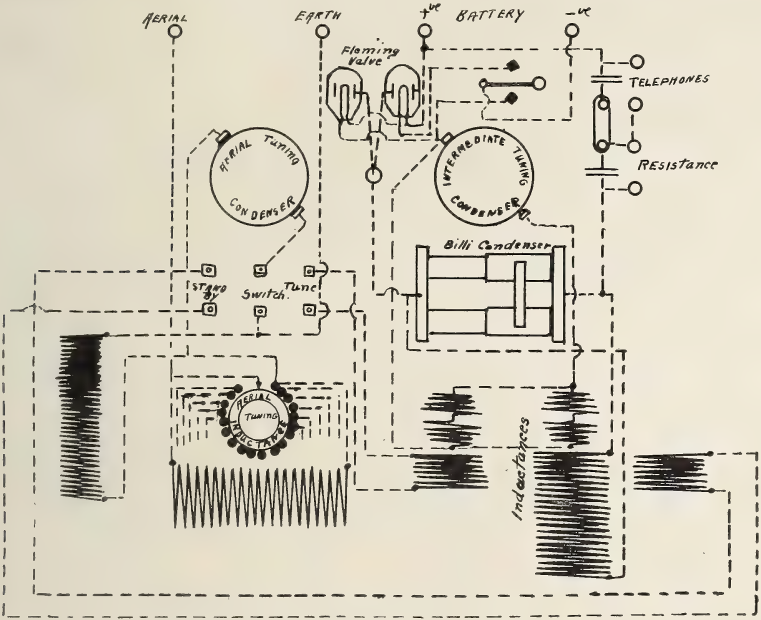

FIG II

DIAGRAM OF CONNECTION OF A MARCONI RECEIVING APPARATUS USING FLEMING VALVE

Effect of Atmospheric Conditions and Daylight.

The first attempt to conduct radio-telegraphy extending over many hundreds of miles revealed the important influence that atmospheric conditions have upon such telegraphy, especially the effect of sunlight upon it.

Marconi conducted experiments on board S. S. Philadelphia on the Atlantic. He noticed that it was possible to receive signals by night when they could not be detected by day. He found that there was very little difference in the signals received by day and by night until he was 500 miles from Poldu. After that, day signals began to weaken and at 1500 miles were hardly perceptible. At daybreak the effect was worse. This is attributed to the fact that light dissipates negative charges of electricity. Some scientists say that the atmosphere especially under the influence of daylight is in a state of ionization and it has been shown that these point charges of negative and positive electricity are set in motion by long electric waves travelling through space and they therefore partially absorb the wave energy.

On account of this effect of daylight messages are sent mostly at night, Press messages being sent from 10 p.m. to 1 a.m.

Another important fact could be mentioned in connection with long distance work and that is in the small degree to which the curvature of the earth seems to affect intercommunication between stations employing earth-connected antenna. It is well known that rays of light and sound are diffracted to some extent around obstacles but the long Hertzian waves from an earthed antenna appear to pass round a one-eighth part of the circumference of the earth without extravagant diminution of amplitude other than that due to distance and atmospheric absorption. The possible cause of the advantageous transmission round the terrestrial sphere is due to the earth connection both of the transmitting and receiving antennae, whereby both these antennae and the earth are practically converted into a single oscillator.

Radio-telegraphy like any other branch of electro-technics has its unsolved problems and it can not be said that a complete explanation of the nature of the propagation of electro-magnetic waves over and round the surface of our globe has been reached which is beyond dispute.

CHICAGO'S SHIP AND DRAINAGE CANAL.*

The Engineering Society of the University of Toronto were afforded a highly instructive address and a rare opportunity on December 12th, when Mr. Isham Randolph, C.E., delivered an illustrated address on Chicago's Ship and Sanitary Canal. While the address was exceedingly comprehensive, it was evident, as Mr. Randolph said, that so vast an enterprise could not be justly dealt with in one address. In fact, Mr. Randolph said the subject could be treated to more advantage under several heads, as, metropolitan, state, interstate, national, and international. In the course of his address Mr. Randolph said Chicago is but 74 years old and the great problems arising from sudden growth may be well imagined. He first took charge of Chicago's work in 1893, a few months after the great fire. At that time Chicago was a straggling sort of a city of about 400,000 population. Streets, in many cases, were below water level an dtremendous operations have taken place to put them in their present condition. Lake Michigan has always been Chicago's source of drinking water. The first lake tunnel ran two miles into the lake, but this was later regarded as insufficient and it was run 2 miles further out. At present there are several running out 4 miles from shore. In 1886 there was a commission appointed concerning this matter of sewage. This commission considered three propositions, (1) an intercepting sewer for conducting sewage to southern part of the lake, (2) a settling basin land filtration plant, but as this affected territory belonging to Indiana that state raised objection to this, (3) carrying the sewage donw the Illinois valley. But with the failure of these propositions the present problem arose. In 1889 the Legislature of Illinois passed a sanitary law, which materially affected Chicago's problem. Whereas 20,000 cubic feet of water per minute was obtainable, they planned a channel for obtaining 600,000 cubic feet per minute.

This canal was to be 200 feet wide on the bottom and 18 feet deep, but in reality it was 202 feet wide at bottom and 22 feet maximum depth. Through the rock the channel was 160 feet wide at bottom and minimum depth was 22 feet. In the rock there was a slope of 2¾ inches per mile and in the clay and sod a slope of about 1½ inches per mile. The cut was made through the rock with a channelling machine and was taken out in 3 stokes with widths at the bottom of 160 feet, 161 feet and 162 feet respectively, these offsets being allowed for the proper manipulation of t he channelling machine. Mr. Randolph was connected with this work for over fourteen years and it assumed enormous proportions during that time. One might reasonably ask whether this enormous expenditure was merited, for the sanitary district of Chicago has an area of only 356 square miles

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* Courtesy of "The Canadian Engineer," Toronto.

.64 of 1 per cent. of the area of the State of Illinois. This comparatively litle area expended $63,000,000 for his prodigious undertaking. The report of the health commissioner of Chicago will perhaps tell whether this really was a paying proposition. The report says that in 1891 Chicago had about the highest death rate from typhoid of any city. The result of these sewage improvements was that from 64.1 per 100,000 population, the death rate in Chicago for typhoid decreased to 23.5 per 100,000 population. And from having the highest death rate of any city it now has about the lowest, having only 15.6 per 1000,000 death rate. According to the report of the health commissioner, 11,148 typhoid deaths had been prevented in 9 years by this system. Mr. Randolph, in his address, expressed the wish that Toronto had such a drainage canal.

The Chicago ship canal is eventually 200 feet wide, 26 ft. deep in mid-stream and 18 ft. deep at the banks, and some 28 miles long. Mr. Randolph has many exceedingly interesting slides of the works, a remarkable feature being the description of the many various appliances used and in some cases devised for the first time to facilitate in the excavating and dredging on this work. Among some of the most interesting slides were those of the Brown level conveyer, which would often complete its operation in 52 seconds in handling 10,000 pounds. At Lockport there are seven gates, interesting from size. They fill gaps of 32 feet, are 20 feet high, have a weight of 62,000 pounds. Two men can raise and lower them in 15-foot pressure of water. The "Bear trap" dam at Lockport is also a remarkable feature—it is 160 feet on the crest, has 12 feet oscillation and the hinges are anchored 20 feet. The placing of this interesting type of structure at Lockport met with much opposition from commissioners and engineers alike and they predicted it would be a failure. It is, however, a decided success. There is also on this canal the so-called "Butterfly" dam, the only one of its kind in the world. It is 184 feet long, 34 feet high and has a pressure on the bottom, when closed, of 3,776,000 pounds. Mr. Randolph solved the hard problems of successful dredging by using the hydraulic dredge. This wonderful machine worked so well that another was built on the works. With the hydraulic dredge the contractors were able to remove 1,400,000 cubic yards of material at a cost of about 5 cents a yard. The Mississippi Navigation Commission following the example of Mr. Randolph has since employed the hydraulic dredge and this is making the navigation of the Mississippi possible. The dredge as used on the Mississippi cost $150,000 and 1,500 yards an hour can be removed with it. The cableway, an invention which was conceived on this Chicago's work, is another mechanical aid that has helped the wor kof excavation in engineering. The aerial dump has done marvels since its invention. Such appliances and the channelling machine, which on the Chicago work cut a gash of ⅜ inch and did 100 superficial feet a day, have made the work of excavation less tedious, and in some cases, at all possible.

In the Panama they are far exceeding now work done on the Chicago canal. This year they have excavated 135 million cubic yards. They excavated only 66 million last year and only 37 million cubic yards the year before last, so a tremendous progress is shown in the speed of excavating. Bridge work over the Chicago River has been very extensive. Eleven of the rolling lift type have been built across the Chicaga and more will be built. The principle of this very efficient bridge is that as the channel span opens the approach span drops. This type has been found very satisfactory.

Mr. Randolph's lecture was listened to with great interest by student and instructor alike, and a hearty vote of thanks extended him by the Society.

THE ENGINEERS' CLUB OF TORONTO.

C. R. Young, B.A.Sc.

For some years past various unsuccessful efforts have been made to establish in Toronto a club offering to engineers, architects, surveyors, chemists, and others engaged in applied science pursuits, all the privileges of the usual social club with technical advantages as well. It has been the dream of almost every member of the original Engineers' Club, incorporated under the Benevolent Societies' Act in 1902, that sometime and somehow the Club should expand into an institution occupying and possibly owning a club house of its own, of sufficient capacity to accommodate within its walls the various technical organizations existing and holding meetings in Toronto. In spite of the many sincere and earnest attempts to bring about this extension, the monetary difficulties in the way proved too much for those who first interested themselves in the commendable undertaking.

Finally, in the early part of the year 1910, a movement was set on foot aiming at the establishment of a "Social Club for Technically Trained Men." The final name was left to be chosen later.

It was recognized that with a membership drawn from engineers and surveyors alone who, up to that time had composed the Engineers' Club, it would be impossible to maintain an advanced Engineers' Club, and that the co-operation of architects, industrial and assaying chemists and all technically trained men working along applied science lines, as well as business men of allied pursuits, must be secured.

It was the intention of the promoters from the first that should the required support be pledged, at the proper time the existing Engineers' Club should be approached, and the two bodies united under a common name, and on a basis equitable to all, and with the strictest justice to each and every member of the original club.

In its early stages the proposition met with much success, and in the course of some four months the names of 360 men, including members of the existing Engineers' Club were secured, who agreed to join the new organization. At this stage, however, an insurmountable difficulty developed—that of securing a charter suitable for such a Club. Finally after much consideration, the organization committee of the "Social Club for Technically Trained" men informed the Engineers' Club that a charter carrying with it the usual club privileges would be more likely granted were it sought, not by the Social Club, but by the existing Engineers' Club, and with this the former organization ceased activity.

Accordingly, at a regularly-called meeting on August 5th., the Engineers' Club of Toronto appointed seven members to apply for a charter under the Ontario Companies' Act, and to follow out, if possible, the procedure essential to the establishment of a Club on the proper basis. It was tacitly agreed that the routine of the Club's business should in the meantime, be discharged by the old Executive Committee.

The desired charter was granted, after much unavoidable postponement, on September 27th., and the following seven members were named therein as provisional directors: A. B. Barry, C. M. Canniff, Willis Chipman, John Galbraith, J. G. Sing, J. B. Tyrrell, and A. J. Van Nostrand. On November 15th, the provisional directors enacted, under seal, after careful consideration and many amendments, a code of new bylaws suitable for the prospective wider life and extended membership of the Club, basing them upon the draft of the "Social Club for Technically Trained Men." These By-laws were finally adopted, without further alteration at a duly called meeting of the Club on December 1st., and the re-organized Club at last began its existence.

At this meeting the directorate was increased from seven to fifteen, the additional eight directors being drawn from the membership of the original Engineer's Club for obvious reasons. The full list thus became as follows: R. A. Baldwin, S. P. Biggs, W. A. Bucke, C. M. Canniff, Willis Chipman, John Galbraith, W. A. Hare, C. H. Heys, E. A. James, J. G. Sing, C. B. Smith, L. J Street, J. B. Tyrrell, A. J. Van Nostrand, and C. R. Young. These directors hold office till February 2nd, 1911, when the first regular annual election will take place, and when it will be possible to secure full representation on the Board, of all the interests concerned.

The provisions of the By-laws respecting membership will, no doubt, be of interest. It is stipulated that the Club shall be composed of engineers, architects, surveyors, industrial chemists, and others, who may be connected with or interested in engineering or allied pursuits. The membership of the Club is limited to 800, composed of 500 resident, 200 non-resident, 25 life, and 75 associate members. Ordinary resident members pay an entrance fee of $50, and an annual fee of $30, while for non-resident members the corresponding fees are $25 and $20. The annual fee is reduced in the two cases to $25 and $15 respectively for prompt payment. Each member must be at least 25 years of age.

The members of the original Engineer's Club are given preferential treatment to the extent of the remission of the entrance fee, since assets of considerable value were automatically transferred to the re-organized Club, on its incorporation under the Ontario Companies' Act. Those members of the old Club who, for any reason, do not wish to take full advantage of the extended privileges offered by the new Club, are, on payment of an annual fee of $5, entitled to the use of the Library, reading room, and lecture hall. The improvements which will be effected in these privileges will considerably enhance the benefits enjoyed by the members of the old Club.

Very soon after the adoption of the By-laws by the members of the Club, a Directors' meeting was held at which officers and members of standing committees were elected and other important business was transacted. The officers elected to hold office till February 2nd, 1911, were: President, C. M. Canniff; First Vice-President, Willis Chipman; Second Vice-President, A. J. Van Nostrand; Treasurer, L. J. Street. R. B. Wolsey was appointed permanent secretary of the club.

It was also decided to engage under a lease renewable on the present terms, for a period not exceeding two years the rooms on the second and third floors of 90-98 King Street West, including the rooms occupied in the past by the old Engineer's Club and the Ontario Association of Architects. These rooms are now being decorated and furnished in a manner suitable for the requirements of the new Club.

The advantage offered by the re-organized Engineer's Club cannot fail to prove highly attractive to technically trained men. With a down-town social club there will be an opportunity for engineers, architects, surveyors, chemists, and those whose pursuits bring them into contact with technically trained men, to meet and become better acquainted. Here members will be in a position to suitably entertain their business friends and clients at luncheon, diner, or otherwise; and out-of-town members may meet their city associates and clients and transact their business. To this end, it is proposed to provide, in conformity with a suitable standard of comfort and elegance, a Grill Room, Smoking Room, Sitting Rooms, Billiard and Card Rooms, and Private

Conference Rooms. A further extension of privileges will be afforded by affiliating with engineering clubs of other cities, and in return for the hospitality extended to Toronto engineers, visiting members of the engineering and allied professions will be entertained here in a befitting manner. Dormitories are being provided to accommodate such visitors as may wish to lodge in the club house during their stay in the city.

While the social privileges of the new club have been first mentioned, the technical side of its activity will by no means be neglected. A reading room, properly isolated in a quiet part of the building will be amply furnished with technical and other journals and magazines, and a first-class technical library will be gradually built up. In this work the various technical societies, meeting in Toronto, will co-operate with a view to economizing resources and avoiding duplication. The lecture room will be used by these organizations for their meetings, and the Engineer's Club itself will provide a technical programme during the winter months. Papers read at its meetings will probably be printed later in the form of proceedings.

A proposal which will, no doubt, be carried into effect, and which will enhance the usefulness of the club, is the establishment of a bureau of information concerning technical work to be done, and men fitted by training to do such work.

A club affording privileges of this character, and free from politics or other clique-forming influences will undoubtedly appeal to all those whose pursuits qualify them for membership. When it is remembered that practically all the benefits offered by the regular social clubs are provided in the Engineer's Club of Toronto, on a reasonably comfortable and elegant scale, and at a fee much less than is ordinarily required by such clubs, it is apparent that the limit of membership is likely to be reached very soon after the re-organized club opens its doors.

THE TEMISKAMING S.P.S. DINNER.

The rapid advance of mining interests in Northern Ontario, and the equal rapidity with which many of our graduates realized the value of the same, were spoken and unspoken lines of thought at a gathering held by them on December 20th., the event of the First Annual Temiskaming S.P.S. dinner. Although the number present did not include all graduates who resided in the district, the dinner was well attended, a huge success, and thoroughly enjoyed.

The toast to "The King" was proposed by Mr. Robert Bryce. In proposing the toast to "The Faculty and Engineering Professions," Mr. C. H. Fullerton drew attention to the increasing importance of the industry of mining, and expressed it as the unanimous opinion of graduates in the Temiskaming district that, in view of the fact that there is at present only one professor and no lecturers in the Department of Mining of the University, something should be done towards increasing the staff of this Department. He reinforced his remarks by stating that this year the class in fourth year Mining, numbers nineteen, and by comparing it with the same class three years ago, consisting as it did of two members. The toast was fittingly responded to by Mr. A. D. Campbell, president of the Engineering Society.

Mr. H. T. Routley proposed the toast to "Our Guests." In replying, Dean Galbraith congratulated the graduates on their achievements in the north country and thanked them for the reception accorded him, and the extreme pleasure he experienced as their guest. He related some interesting reminiscences of a trip into the Temiskaming country some six years ago, before mining in Cobalt had come into existence.

"Sister Institutions," proposed by Mr. E. V. Neelands, was responded to by Mr. W. S. Dobbs, representing Queen's Unievrsity. Mr. A. A. Cole, who was to have represented McGill, was unable to be present. Messrs. Thorne, Jupp, and Sutcliffe were called upon to respond to "Our Wives and Sweethearts" proposed by Mr. B. Neilly.

The dinner was such a splendid success that its annual recurrence will undoubtedly be looked forward to with interest.

In addition to the banquet, the visit of Dr. Galbraith comprised a trip underground at the O'Brien and Crown Reserve mines, and through the concentrating mills at the O'Brien, Silver Cliff and Nova Scotia properties.

It might be well to cite a few figures from an agricultural pamphlet, published a few months ago by the Ontario Legislative Assembly, regarding the rapid growth of the Temiskaming District.

"So recently as six years ago there were but 2,000 people in Temiskaming, while now there are between 50,000 and 60,000.

Englehart, a divisional point of the T. and N. O. Railway, is

25 miles north of New Liskeard; only four years old, it has a population of about 800, and is a promising agricultural centre. Westward, at the terminus of the branch line of the T. and N. O. from Englehart, is Charlton, a thriving village at the foot of Long Lake.

New Liskeard, on the T. and N. O., at the head of Lake Temiskaming, is 113 miles north of North Bay, and 340 miles north of Toronto; its population is 3,000, it has several important industries, and is in the midst of a large, well-settled agricultural district.

Haileybury, five miles to the south, is an attractive residential town, with a population of 4,000.

Cobalt, four or five miles farther south, has world-wide fame for its deposits of silver, being one of the most important mineral deposits discovered in the last forty years. Population, 5,500. Farther south is the growing town of Latchford."

It is also interesting to note that practically four-fifths of the land surveying in Temiskaming District is done by "School" men. The firm of Routley, Summers, and Malcolmson have surveyed over 700 mining claims during the past two years. Sutcliffe and Neelands, besides doing a large land survey practice, are municipal engineers of Cobalt, New Liskeard and Cochrane.

In another department is given a list of graduates in this section of Northern Ontario.

METHODS OF SECURING MAXIMUM EFFICIENCY IN MANUFACTURING AND CONSTRUCTION.

By William M. Towle, B.S.*

Much is being said and written about conservation of natural resources. It is time that the American people paid more attention to the preservation of their heritage. With the great extent of territory and wealth of natural resources a tendency to run over and pick out the best and leave the rest to destruction and waste has been developed. In the manufacturing industries with the abundant supply of raw material and good home markets this same tendency is shown. Now when protection is lowered and the markets of the world are attracting attention it is necessary to consider the costs of manufacturing in all the details.

The cost of the manufactured product is made up of the cost of the raw material, labor, supervision, interest, and depreciation of plant, and expense of operating. In the ultimate analysis of the cost it will be found that labor represents nearly the whole amount, for the raw material before any labor is put upon it is but a small fraction of the whole cost of the article. Therefore, to reduce the cost of the finished product it is necessary to increase the efficiency of labor as no one wishes to reduce the wages of the laborer. Many schemes have been thought out and tried to accomplish this desired result. The most effort has been put on the wage side of the problem. As a general thing these schemes have been successful only when carried out by their originators or by some one in full sympathy with the plan.

The principal plans for rewarding labor are the day's-work, piece-work, premium or bonus, and profit sharing. The day's-work plan by which the laborer is paid a stipulated sum for the hour, day, or week, is the plan liked best by the workmen, for as a general thing they are willing to give a fair day's work for a fair day's pay. They look upon all other plans as methods to get more work out of them for the same money. While this is true to a certain extent, the other plans are mutually beneficial. The workman who is ambitious and willing to work harder gets more wages, and the manufacturer gets more work done with the same plant, thereby increasing the profits on the capital invested.

The profit-sharing plan, the most beautiful in theory is perhaps the poorest in practice. There are drawbacks in making a stockholder of an employee. While he is doing a good day's work the other workmen will criticise him as trying to "set a pace" and during a strike he loses influence with the other workmen. The average workman is ready enough to share in the profits, but not to share in the risks of industrial or commercial enterprises. The workmen have exaggerated ideas of the profits, and not having access to the books are apt to think that they are not getting their full share.

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* Professor of Industrial Engineering, Clarkson Memorial School of Technology.

Some manufacturers share their profits by making an out-and-out gift once a year to all of their employees who do not in any other way share in the profits. Generally these gifts are from 5 to 10% of their annual earnings. Another form of profit-sharing is a pension, and a sick relief plan for the benefit of the workmen and their families. This is eminently proper, for each industry should bear its own burden caused by accident, sickness, disability, and old age.

Most employers do not know what the men and machines are capable of doing. If working on the day's-work plan the men are liable to set an easy pace and the production be far below the amount possible. If a piece-work system is installed the workman is left to devise ways of increasing the output. When the earnings become large the price is cut and the usual dissatisfaction and trouble ensue.

The greatest gain in securing the maximum efficiency in manufacturing can be obtained by conserving the energy of the workmen. This can be done by investigating and studying all the operations performed by the workman, in designing and arranging the tools, machines, and appliances; and in planning the method of doing the work that the workman may produce the greatest amount of output with the least expenditure of effort. This can be secured only by the hearty co-operation of the employer in providing the best of everything wherewith to do the work, and by the workman in using such to the best advantage.

Much has been done by several engineers who have made a systematic and analytical study of each and every motion and operation required to produce a given result, and who have devised means and methods to produce the best and quickest results at the least cost. In Mr. F. W. Taylor's paper, "The Art of Cutting Metals," before the American Society of Mechanical Engineers, the topics such as developing a high-speed steel, determining the proper shape of the cutting tools, and deciding about speeds, feeds, etc., were but incidentals to the study and development of the larger problem. Mr. Taylor's method involved a study of the various operations of a job and in timing these operations; then in changing the conditions in accordance with his time studies, until the minimum time in which the best worker could perform them was determined; and finally in compelling all the workers to conform to the methods of the most skilful operator, and to equal his time, by means of bonuses and penalties.

Every operation, for instance, is made up of a series of motions on the part of the worker. A careful study of these motions will eliminate all the useless movements of both man and material. This will give a set of standard operations to be followed thereafter.

It is thus seen to be a large problem to secure maximum efficiency in manufacturing. It involves providing the proper tools, appliances, and surroundings, and what may be considered the most important of all, namely, the employment of workmen of the proper physical and mental constitution to carry out to the letter the instruction given them for making the standard motions.

The average employer thinks that this is too large a problem to be studied seriously. He thinks it impracticable of execution. In this, however, he is very much mistaken. A series of articles by Mr. Frank B. Gilbreth, in "Industrial Engineering," shows how the adaptation of the standard motions to the trade of bricklaying has increased the efficiency of the men so that they can lay many more brick per hour and earn much more money per day, and to such an extent that for men working under the old methods there is hardly any comparison possible.

Mr. Taylor has worked out his system in some of the largest and most successful shops in the country. Mr. Gilbreth is likewise successful as a contractor, and his men all work according to the standard motions developed by him. The methods of both of these men have therefore withstood the test of commercial use.

Thus we see that to enable the manufacturer to turn out more and better products, at less cost, more attention must be paid to production engineering. New methods, tools, and facilities are expensive, and will be profitable only when the production is large. The overhead and distributing expenses of any manufacturing establishment are great; therefore, there must be a large output to share this burden in order to keep the cost per unit small. This has a tendency to work along the line of division of labor. The manufacturer becomes a specialist in a few things instead of producing a large line of goods.

It is this tendency towards specialization which has caused so many companies manufacturing similar products to unite their forces. Each factory confines itself to a few lines of work for which it is best fitted. This method eliminates ruinous competition in distribution, reduces the overhead and operating expenses, increases the efficiency of each plant, lessens the cost of production, and secures maximum efficiency in manufacturing and construction.

WHAT OUR GRADUATES ARE DOING

J. H. Caster, '07, is in the Production Dept., Canadian General Electric Co., Peterboro.

Walter Jackson, '07, is with the Ontario Power Co., Niagara Falls, as field engineer on construction and extension of works.

S. B. Iler, '08, is with the Seymour Power and Electric Co., Belleville, Ont.

A. D. Dahl, '08, is chemist with the Don Chemical Co., Midland, Michigan.

P. H. Buchan, '08, is in the Maintenance of Way Department, B. C. Electric Ry. Co., Ltd., Vancouver.

H. F. Shearer, '08, is testing engineer in the power apparatus Dept., Bullock Electric Mfg., Co., Norwood, Ohio.

N. G. Madge, '08, is chief chemist with the Continental Rubber Co., of New York.

F. C. Lewis, '08, is designing and estimating in the Railroad Bridges Dept., of the American Bridge Co., Chicago.

C. B. Langmuir, '09, is sales engineer for Factory Products, Limited, Toronto.

Stan. Stroud, '09, is with the Westinghouse Elect. and Mfg. Co., Pittsburg.

C. G. Titus, '10, is manager of the Bartlett Mines, Gowganda.

R. J. Spry, '10, is metallurgist for the B. C. Copper Co., Greenwood, B. C.

H. C. Bingham, '10, is assistant engineer in City Engineer's Dept., Moose Jaw, Sask.

L. J. Ireland, '07, is superintendent of Midland Construction Co., Ltd., in charge of the Seymour Power and Electric Co's construction work.

G. G. Bell, '05, is with Sawyer and Nuulton, of Portland, Me., as designer in power plants, pulp mills and general engineering projects.

C. J. Harper, '09, is in the employ of the General Electric Co., in Pittsfield, Mass.

E. A. Thompson, '09, is in the electrical department of the office of Smith, Kerry and Chace, Toronto.

L. H. Robinson, '04, is resident engineer for the Transcontinental Railway at Superior Junction, Ontario.

W. A. Begg, '05, has been connected with the Department of Public Works, Saskatchewan, on drainage surveys and road divisions.

E. E. Mullins, '03, has for some time past been mechanicel engineer for the United Fruit Co., operating in Central America and the West Indies. The company owns and operates some 2,000 miles of railroad (about 600 miles of which are in Costa Rica), and 90 steamships. Mr. Mullins has the supervision of repairs and improvements of the mechanical equipment of the railway and steamship lines.

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EDITORIAL

Aviation's Progress is Costly.

Almost daily the press relates the death by accident of one after another, who has overreached his equilibrium in the atmosphere and has become a victim through "the feel of the air."

"Suddenly the machine struggled from his control, skidded, and cast itself downward to a heap of ruins."

Such passages meet our reading gaze so frequently, now-a-days that we wonder if the glory of achievement is really worth the sacrifice. Disaster seems to befall expert and beginner alike. In the majority of cases the cause will never be known. An imperfection in the mechanism, a fatal vagary of the upper air currents, or of the cast-iron will power of the operator, due to nervous tension, any or none of these may result in an added fatality to the already lengthy list.

Although the days of knight-erranty are a part of history, reflected but seldom, one might easily form a mental comparison of the jousts and tournaments of old with to-day's passion to excell in the aviation world.

In the time of automobile infancy there were also fatalities, due to the same degrees of ignorance, impractibility and each of caution that summarize the present dangers of mechanical flight. But these were suppressed by strict enforcement of judicious rules and specifications—the result was a speed transition of the automobile from the sportsman's experiment to an important accessory to the business world. It is safe to say that its rapid advance was partly due to the timely laws which governed its manipulations.

There are few of us who do not see in the aeroplane, even a greater aid than in the automobile. Aerodynamics has long been a subject for deep study and experiment. Men have seriously attempted to build flying machines since the beginning of the sixteenth century, and altho the present revival of interest in aeronautics has witnessed the accomplishment of a very great deal, mechanical flight may be held in abeyance, unless steps are taken to lessen the likelihood of loss of life and limb. In this regard Glenn H. Curtiss, one of the world's foremost aviators, writes:

"All efforts to improve and develop aviation will be futile. unless immediate steps are taken to guide and direct this development. The government, assisted by aero clubs, and aviators of experience, should take the matter in hand and guard against recklessness, which not only involves the lives of the aviators but also endangers the lives of spectators. Rules and regulations will not accomplish this purpose. The air is a great highway that has just been opened to the public. It must be regulated as are other great highways."

Although aeroplanes have been a marketable product for about a year, it is a question whether the industry a decade hence will in any way compare with the automobile business today unless the great degree of hazard is soon eliminated.

S.P.S. men as Aviators.

Among our graduates F. W. Baldwin, '06, and J. A. D. McCurdy, '07, have met with good measure of success in aeroplane manipulation. Both are members of the "American Aerial Experiment Association" organized by Dr. Alexander Graham Bell, and of which Lieut. Selfridge, who met death in an aeroplane accident with Orville Wright, in 1909, was secretary.

Last Autumn, Mr. McCurdy arrested the attention of the scientific world when, while operating his machine at an aviation meet at Sheepshead Bay, he successfully transmitted the first wireless despatch from an aeroplane. His message read thus:

"Another chapter in aerial achievement is recorded in the sending of a wireless message from an aeroplane in flight."

Although his investigations have not resulted in any world beating aerial flights, Mr. C. H. Mitchell has devoted much thoughtful study to the science of flight, and has kept closely in touch with the progress that has been made to date. Mr. Mitchell will present a paper on this subject to the Engineering Society, at a general meeting in the near future. Undoubtedly the lecture will be one of the most interesting of the year, and those with whom the idea of mechanical flight is popular, are invited to be present.

CLASS '05 DINNER.

A Re-Union dinner of the Post-Graduate Class of 1905 and the Graduating Class of 1904 of the Faculty of Applied Science and Engineering was held on Wednesday, December 28th, 1910, at the St. Charles Hotel, Toronto. Twenty-six of the ninety original members of the two classes were present. Dean Galbraith was the guest of honor and in reply to the toast to "The University and the Old School" spoke reminiscently of the foundation of the School of Practical Science and of his connection with it in the early days. Mr. Kenneth Rose, '88, having heard of the dinner in Cobalt, dropped in unexpectedly and was accorded a hearty reception. Messrs. C. E. Bush and J. H. Craig of the "Science Octette" contributed music for the occasion. During the evening it was decided to hold another re-union in five years and the following list of new officers was elected to carry out this project: President, E. A. James; Vice-President, W. F. Wright; Secretary-Treasurer, W. W. Gray; Councillors, A. M. Campbell, A. Gray, R. S. Smart, B. B. Tucker. The chair was occupied by the retiring President, Mr. C. R. Young.

At a joint meeting of the Engineers' Society of Nova Scotia, and the Nova Scotia Institute of Science, in December, Mr. A. V. White, a graduate of '92, spoke to some length on the early history of Astronomy, including an investigation of the proofs usually given in support of the fundamental tenets of the copernican system. The discussion proved a valuable one to those who were fortunate in being present, and showed Mr. White's thorough familiarity with the history and theory of the subject. Mr. White has recently been making some engineering investigations in that province for the Conservation Commission of Canada.

The Annual Dinner

The preparations for the twenty-second annual dinner of the Engineering Society are well under way and indicate another addition to the list of successes of similar functions of the Society.

Last year the dinner was the most successful ever held, and it is the aim of the present management to surpass it, as well as its many predecessors.

The twenty-first annual dinner was an important event, owing to the fact that approximately one hundred and fifty members of the Canadian Manufacturers' Association were in attendance as guests, and departed with a much enlightened idea of the prominence of this Faculty of the University and its importance to them.

The twentieth annual dinner of the Society was almost equally important. On this occasion the guest list comprised a large number of members of the Canadian Society of Civil Engineers. To them the excellent development of the Faculty of Engineering was strongly brought out, and they carried away a better impression, perhaps, than the Society had anticipated.

This year the Engineering Society is inviting members of the Board of Trade from every part of the province. Without doubt this is another step in the right direction, as this large and influential body should be well aware of the progress and possibilities of the University of Toronto; and to the number that will be in attendance, our views regarding the desire and willingness of the University to increase the much-needed intercourse between both bodies, will, in all probability, be presented.

Ceramics Again

The January "Applied Science" of last year contained an article pertaining to the efforts that had been made to establish a course in Ceramics at the University of Toronto. That the Clay Products Manufacturers' Association have not diminished their eagerness to further the enterprise, is indicated by the fact that the question arose and was again lively discussed at their annual convention in this city some little time ago.

President McCredie, in his address, drew attention to the pressing need of the establishment of a chair of Ceramics in the University, as the manufacture of clay products required young men with a thorough training in this branch of science. Other members, especially Mr. S. J. Fox, M.P.P.. and Mr. J. S. McCannell, emphasized the demand for such men in the ceramic industry.

The attitude taken by the Board of Governors several years ago, when the report prepared by Dr. Ellis, and others, who had investigated the progress in a number of universities in the United States, was not a favorable one in the interests of the Canadian Clay Products Association and its proposal. Its decision came rather as a surprise, as the agitation had met with the approval of the Faculty of Applied Science and of the University Senate.

In the article mentioned, Mr. D. O. McKinnon states clearly the scope such a course would have and what it might accomplish.

Those who are interested in the manufacture of clay products are asked to again read the article and to look forward to a similar article from another member of the Association.

THESES

The fourth-year men, with the exception of the chemists and miners, have submitted their theses for examination. A list of them is given below:

E. P. Bowman—Magnetic Declination, Inclination and Intensity.
A. E. Glover—Water Supply and Irrigation with special attention to methods in practice in the United States.
J. S. Galletly—Photo-Topography.
J. E. Gray—Determination of Latitude.
O. W. Martyn—Determination of Longitude.
E. A. Neville—Theory and Practice of Road Location.
N. C. Stewart—Determinate of Latitude.
W. G. Amsden—The Construction of the Engineers' Transit and Level.
J. A. Baird—Drainage.
Thos. Barber—Dams and Forebays.
H. A. Barnett—Power Development.
W. M. Carlyle—Concrete Foundations, their Construction and Design.
H. S. Clark—Rock Excavation in Road Work, Tunnelling, etc.
C. G. Cline—River Discharge for Hydraulic Power Purposes.
G. A. Colquhoun—Street Paving.
R. L. Dobbin—Steel and Iron Bases for Columns.
A. W. Fletcher—Concrete Culverts.
W. C. Foulds—Iron Castings.
A. Fraser—Malleable Cast Iron.
M. M. Gibson—Dams, their construction and design.
V. A. E. Good—Fireproof Floors.
N. J. Harvie—Turbine Governors, their design, and methods of operation.
R. H. Johnston—The Purification of Sewage.
J. C. Keith—River Discharge.
G. A. Kingstone—Specifications for Concrete Reinforcing.
S. Knight—The Construction and Maintenance of Public Highways.

J. N. Leitch—Piles and Piling.

J. A. MacDonald—Reinforced Concrete Floor-Slabs.

J. B. Macdonald—Specifications for Structural Steel Work.

G. A. Macdonald—Irrigation—A description of the construction and application of various systems of design.

D. D. MacLeod—Reinforced Concrete Dams—their construction and design

S. G. McDougal—Permanent Railway Structure and Estimates.

J. McNiven—The Theory and Design of Compression Members.

W. H. Marten—Water Filtration, dealing with the most recent developments.

E. S. Martindale—Breakwaters—A treatise of their construction and efficiency.

F. S. Milligan—Bituminous Pavements—Construction of various types.

F. R. Mortimer—The Principles and Practice of Railway Signalling.

A. H. Munro—Preliminary Conditions in the Development of Hydro-electric Power.

V. A. Newhall—The Practice of Irrigation in the West.

F. T. Nichol—Reinforced Concrete Floor Construction—Various forms of construction and design.

C. M. O'Neil—Construction and Properties of Reinforced Concrete Columns, Beams, etc.

R. B. Pigott—Reinforced Concrete—Principles governing construction and design.

R. B. Potter—The Making of Good Roads.

W. S. Ramsay—Water Supply and Water Purification.

C. E. Richardson—Dams—General description of the construction of dams.

J. C. Street—The Purification of Public Water Supplies.

C. C. Sutherland—Sewage Disposal—A description of methods now in common use.

A. D. Sword—Diving—together with other applications of compressed air to submarines.

L. T. Venney—Concrete Highway Bridges.

C. M. Walker—Cement—its properties and the various methods employed in its manufacture.

G. A. Warrington—Highways—with special attention to location and surfacing.

L. A. Wright—Concrete Bridges.

W. S. Young—Road Improvement.

D. C. Blizard—Tungsten Lights, with reference to Feature, Field, and Effect.

L. S. Cockburn—Storage Batteries—The application, installation, care and maintenance of batteries; synopsis of the various systems in use.

APPLIED SCIENCE

A. G. Code—The Development of the Incandescent Light—from the age of experiment to its present efficiency.

C D. Dean—Suction Gas Producers—their development and construction; general description of plants and units comprising them.

W. P. Dobson—Wave Forms of Force Periods which occur in Alternating Current Circuits.

J. W. Ferguson—Suction Gas Producers.

F. T. Fletcher—The Development of the Incandescent Lamp, with reference to the Tungsten Lamp.

C. B. Leaver—Suction Gas Producers, Gas Analysis, etc.

H. G. MacMurchy—Modern Methods of Electric Power Distribution.

H. J. MacTavish—Integrating Watt-meters—Principles, construction, and application.

C. Holmes—Storage Batteries.

D. D. McAlpine—The Induction Generation, its theory, application and principles of construction.

H. O. Merriman—The Protection of Electric Circuits from Lightning.

P. E. Mills—The Gasoline Engine as applied to Modern Automobiles.

C. G. Parker—High Voltage Transmission.

A. L. Sutherland—The Prevention of Smoke in Boiler Plants.

R. M. A. Thompson—The Electrification of Steam Railways, together with a description of the various types of railway control.

K. M. VanKallen—Oil Switches.

M. B. Watson—The Electrical Equipment of a Modern High Tension Distribution Station.

B. W. Waugh—Wireless Telegraphy.

F. C. White—Voltage Regulation—the application of vector diagrams to the same.

G. K. Williams—Gasoline Carburettors.

A. W. Youell—Air Compressors.

S. E. Craig—Pulp Making Machinery.

J. R. Burgess—Gas Producers—A description of various types in use, their operation and efficiency.

A. W. Chestnut—Refrigeration—Application of the general principles to refrigeration requirements, and a description of the machinery in use.

D. C. Chisholm—The Preservation of Timber.

C. R. Ferguson—Steam Turbines—The theory governing their application, the field, and efficiency.

H. Gall—Municipal Railways and Thoroughfares.

V. F. Gourlay—Tool Steel—Its properties, manufacture and a synopsis of the various uses to which it is applied.

H. C. Johnston—Dams—Design and various forms of construction.

J. I. MsSloy—Modern Automobile Engines.
C. H. Phillips—Producer Gas Engines.
L. R. Wilson—The Application of Nickel Steel and other High Tension Alloys to Modern Bridge Construction.
M. H. Woods—The Details of Gasoline Engine Details.
H. C. Barber—High Tension Underground Cables.
T. H. Crosby—The Parallel Operation of Alternating Current Generators.
R. G. Lee—The Single Phase Induction Motor.
A. S. McCordick—Railway Converter Sub-Stations.
C. E. Palmer—Storage Batteries and their Application.
K. K. Pearce—Electric Locomotives—A description of various types of electric train control, and of modern brake systems.
R. A. Sara—Organization for Electric Distribution Companies.
A. Schlarbaum—Protective Apparatus.
M. W. Sparling—Switchboards—A synopsis of their construction and equipment.
J. B. K. Fisken—A Gothic Church.
T. C. McBride—The Design of a Public Library.
W. S. Wickens—The Design of a Post Office.
C. P. Van Norman—Transformers—A description of general principles, and the investigation of vector relations of the transformer.
R. J. Arens—The Manufacture of Potassium Bichromate from Chrome Ores.
J. H. Harris—The Manufacture of Soap.
J. A. MacKinnon—The Filtration of Water for Domestic Purposes.
J. H. Adams—The Limits of Amalgamation of Porcupine Gold Ores.
E. T. Austin—High Silica Slags in Copper Smelting.
D. G. Bissett—The Electrolytic Assay of Zinc Ores.
A. F. Brock—The Cyaniding of Concentrates of Porcupine Ore.
A. D. Campbell—Cobalt Milling Methods.
V. H. Emery—Cyanide Treatment of Slimes from the Porcupine Gold Ores.
J. M. Foreman—Acid Open Hearth Slags.
R. L. Greene—Association of the Ores at the O'Brien Mine Cobalt.
P. E. Hopkins—Cyanide Treatment of Sands from Porcupine Gold Ores.
F. L. James—The Electro-analysis of Zinc.
H. G. Kennedy—Mine Timbering of Metalliferous Mines.
G. L. Kirwan—Losses in the Fire Assay of Silver Ores.
A. W. R. Maisonville—Malleable Castings.
A. C. Matthews—The Basic Open Hearth Slags.
W. E. Newton—The Electro-magnetic Separation of Zinc Minerals.

A. L. Steeel—Investigation of the Losses in Assaying of Gold-bearing Ores.

H. M. Steven—Cyaniding versus Amalgamation for Gold Ores.

T. Walton—Blast Furnace Slags.

S. A. Wookey—The Interpretation of Topographic Maps, with some reference to the Geology.

SCHOOL MEN IN THE NORTH

Some of the "School" men at present residing in the Temiskaming District:

In Cobalt—Chas. Williams, M. T. Culbert, Robt. A. Bryce, A. Carroll, B. Neilly, E. V. Neelands, S. A. Thorne, H. E. Colley, Herb. Clark, G. Pace, D. Duthie, A. D. MacDonald, Geo. Adams.

In New Liskeard—E. W. Neelands, H. W. Sutcliffe, C. H. Fullerton, F. Dines, P. Phillips, W. J. Johnston, W. J. Blair.

In Haileybury—H. T. Routley, W .Malcomson, G. F. Summers, Jno. Pierce, E. D. Eagleson, A. H. A. Robinson, A. E. Jupp, Mr. Gouldie, H. Southworth, Eric Ryerson, Robt. Laird, Geo. Johnston.

In Cochrane—R. Harthstone, E. Nickels, P. A. Laing, W. M. Bishop, J. H. Dawson, Gordon Calvert, Chas. Peterson, Erie Ryerson, Buzz Nelles.

In Porcupine—E. R. Dann, F. Bedford.

In GowGanda—C. Titus, Wilkie Evans.

In North Bay—R. Keys, P. Maher, Harold Keefer, Jno. Shaw.

In Sault Ste. Marie—Jno. Laing, Ken. Ross.

In Sudbury—Mr. Stull, Mr. Demorset.

OBITUARY

We have to announce the death in Buenos Ayres, Argentine Republic, of Roy B. Ross, '05. Mr. Ross was 26 years of age, and had been in Buenos Ayres for two years in the interests of the Marine Signal Co., Ottawa. A full obituary will appear in the April issue.

WHAT OUR GRADUATES ARE DOING.

F. G. Allen, '07, is with the B. F. Sturtevant Co., Hyde Park, Mass., as assistant to the chief consulting engineer.

A. H. Arens, '06, is in Inverness, N.S., as resident engineer for the Inverness Railway and Coal Co.

E. G. Arens, '09, is with the H. D. Symmes Co., of Niagara Falls.

A. R. Raymer, '84, is assistant chief and signal engineer for the Pittsburgh and Lake Erie R. R. Co.

Wm. J. Chalmers, '89, is with the Vanport Beaver Co., Pittsburg.

G. H. Richardson, '88, is managing director of the Yellowhead Pass Coal and Coke Co.

G. E. Sylvester, '91, is chief engineer for the Canadian Copper Co., Copper Cliff, Ont.

A. T. Beauregard, '94, is laboratory engineer for the Public Service Corporation of New Jersey.

Harold Rolph, '94, is secretary for the John S. Metcalf Co., Limited, Montreal.

A. E. Blackwood, '95, is manager of the Sullivan Machinery Co., New York city, manufacturers of quarry and mining supplies and diamond drills.

H. W. Saunders, '01, is division engineer of the United States Coal and Coke Co., having charge of 12 of their mines.

Wm. Christie, '02, is engaged in D.L.S. work at Prince Albert, Sask.

A. A. Wanless, '02, is lecturer and demonstrator in the Sydney Mines Technical Schools, Nova Scotia.

A. G. Lang, '03, is underground superintendent for the Toronto Hydro-Electric System.

H. F. White, '03, is assistant superintendent for the Geo. White & Sons Co., Ltd., London, Ont.

John Paris, '04, is resident engineer on construction for the T. C. Ry., at La Tuque, Quebec.

W. S. Pardoe, '04, is instructor in hydraulics and sanitary engineering, University of Pennsylvania, Philadelphia.

Thos. D. Brown, '06, is with the Canadian Fairbanks Co., in their Calgary office.

W. P. Near, '06, is resident engineer on trunk sewer construction, Main Drainage Dept., City Hall.

Geo. W. Bissett, '06, is mill superintendent for the Canadian Exploration Co., Ltd., at Naughton, Ontario.

D. W. Marrs, '06, is designer of structural steel for the Riter Conley Mfg., Co.

M. K. McQuarrie, '07, is terminal engineer for the C.P.R at Vancouver, B.C.